



Sequential Events Control System (SECS) Overview

Sequential Events Control System (SECS)

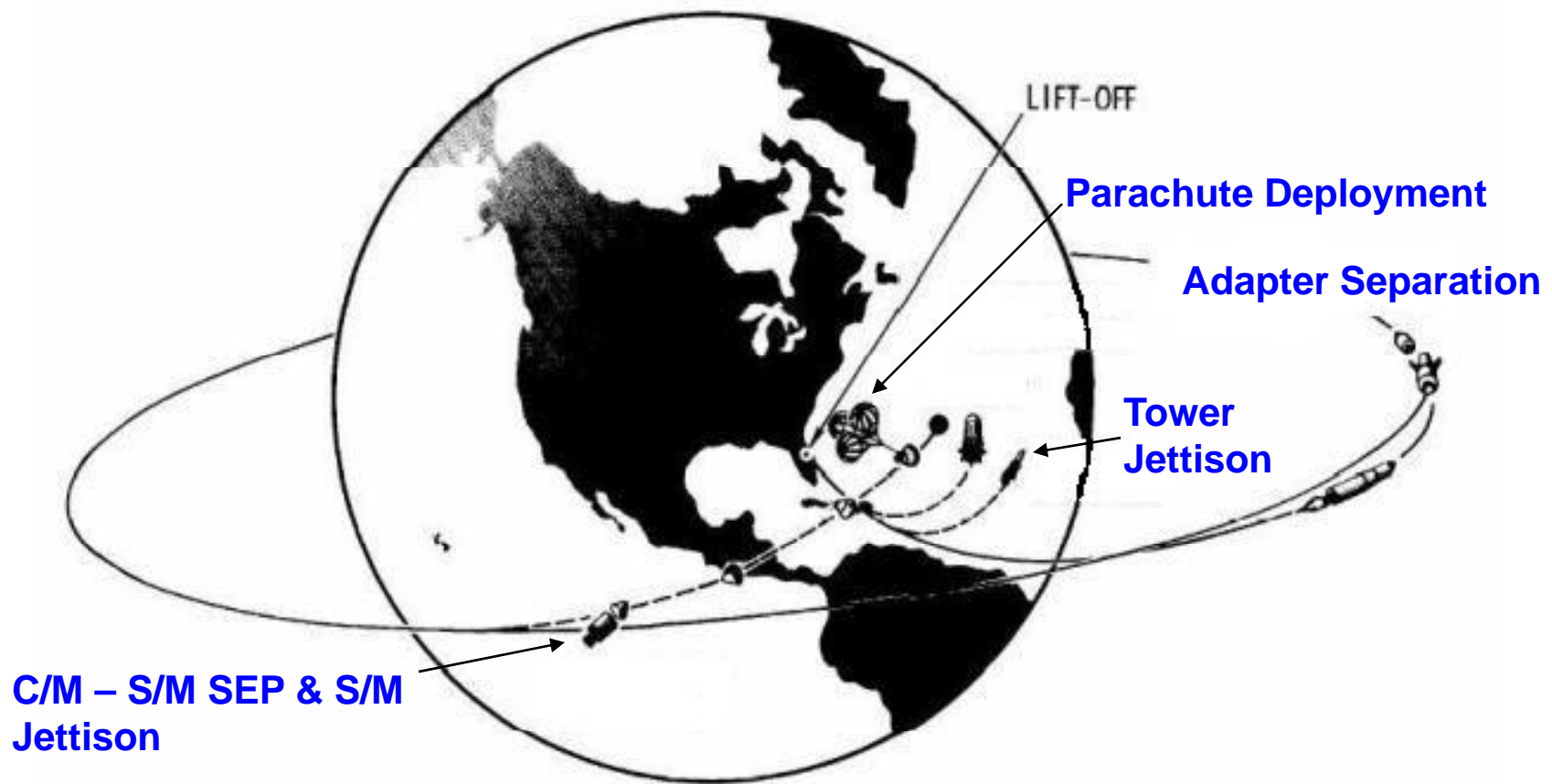
- ❑ This lesson will cover the Sequential Events Control System (SECS), which is the Apollo spacecraft subsystem that controls the automatically sequenced functions during the mission and during any aborts that could be performed. Included in this lesson are its general architecture, its integration into and use of the spacecraft's other systems, and details on the functions it is responsible for controlling during the mission.

Objectives:

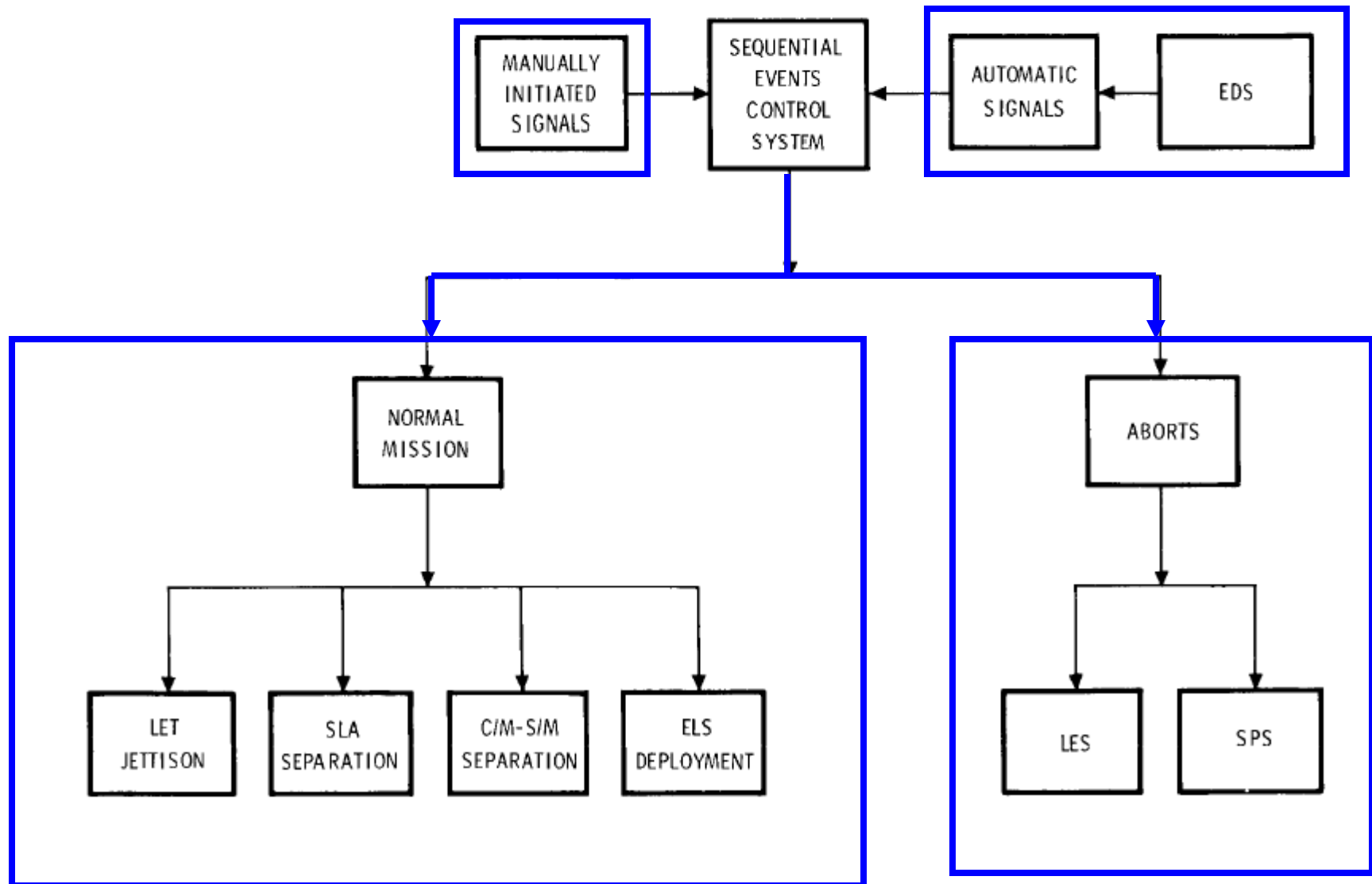
- ❑ The student will be able to understand the System's Architecture
- ❑ The student will be able to describe the major components in the System
- ❑ The student will understand the major System Functions

System Description

- ❑ The Sequential Events Control System (SECS) is the Apollo spacecraft subsystem which controls the automatically sequenced functions during ascent, entry, and any mission aborts

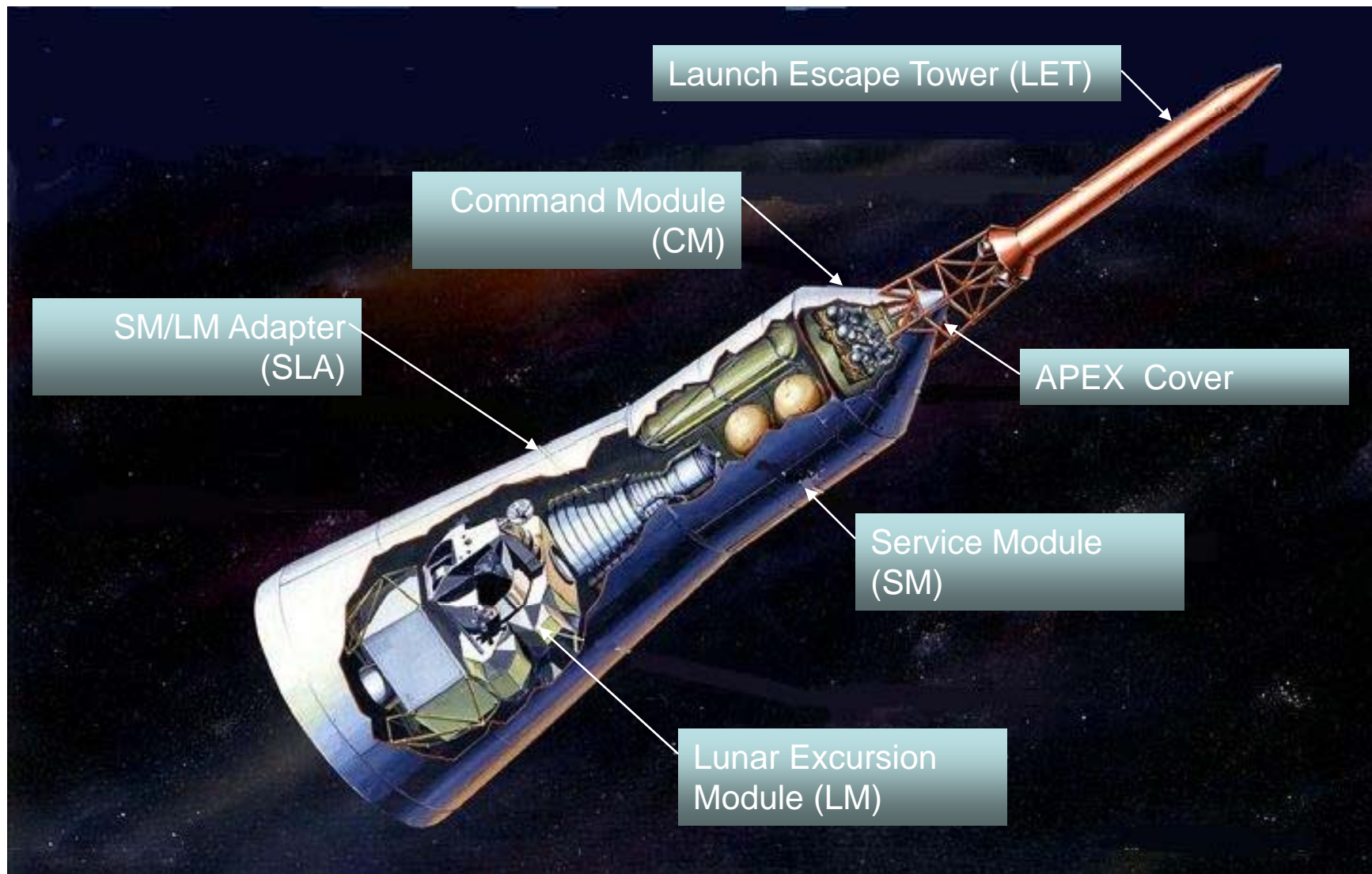


System Functional Diagram



System Vehicle Interfaces

- ❑ The SECS interfaces across several vehicle components which include:

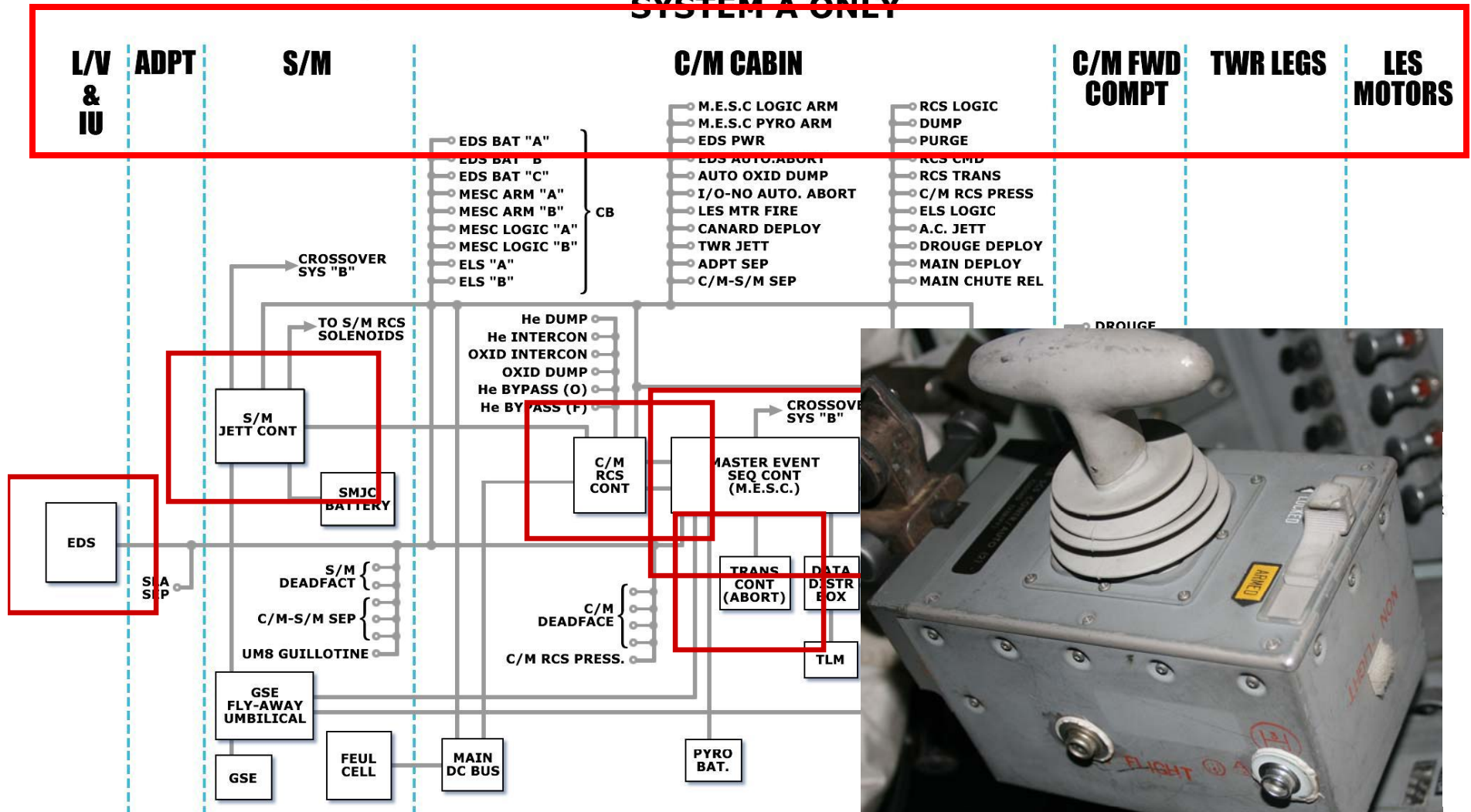


System Controllers

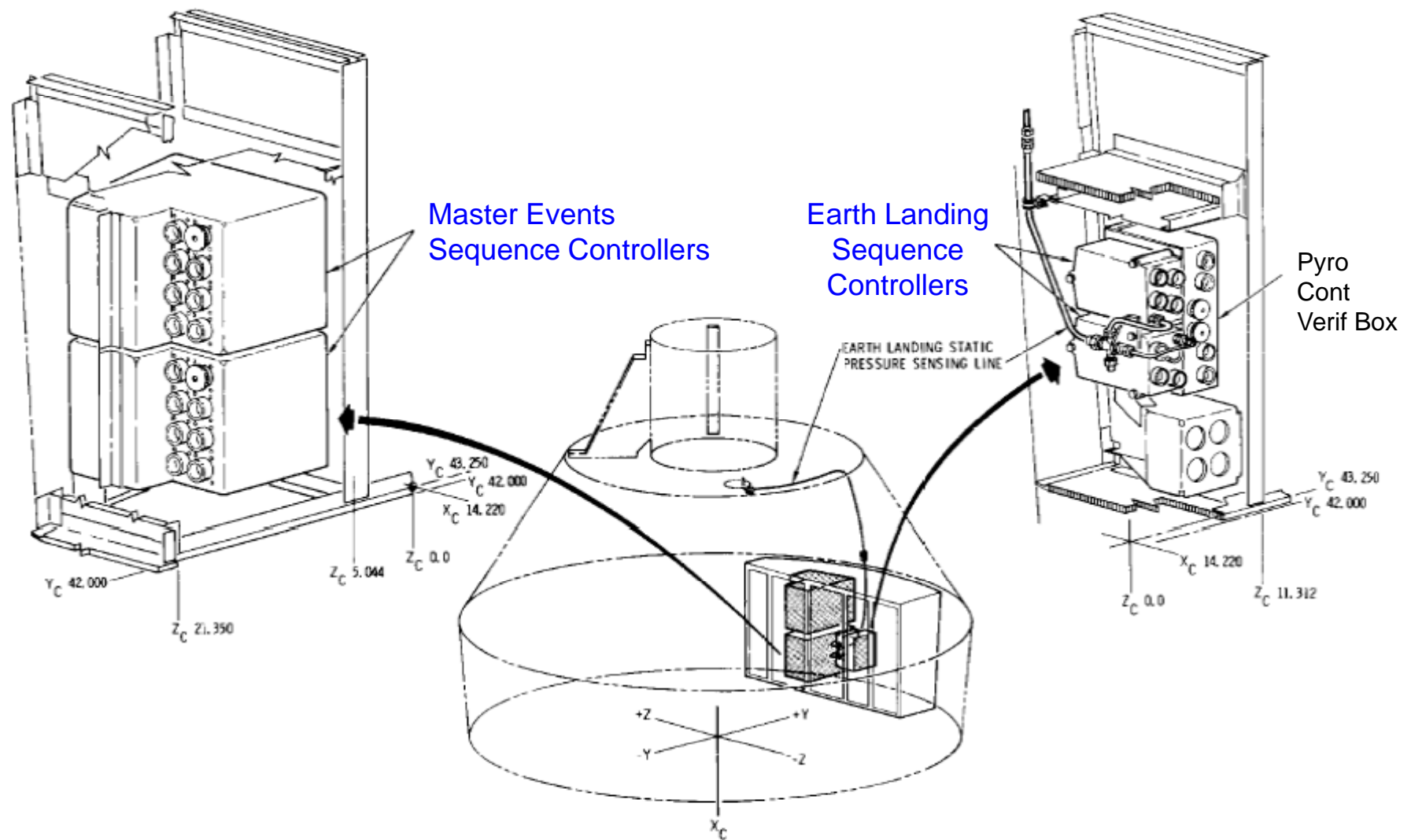
- ❑ Contained within the SECS is the Master Events Sequence Controller (MESC), which is the master controller of the entire system. The MESC interfaces with the following subsystem controllers:
 - Emergency Detection System (EDS)
 - SM Jettison Controller (SMJC)
 - Command Module (CM) Reaction Control System (RCS) controller (RCSC)
 - Earth Landing Sequence controller (ELSC)
 - Translation Controller
- ❑ Feeding into these controllers are numerous relays, time delays, and baroswitches that enable discrete events to occur in a prescribed order, at specific times or altitudes.
- ❑ All components inaccessible to the crew for maintenance purposes. Redundancy accomplished by having two identical systems, A and B, that can each accomplish all requirements.

System Architecture

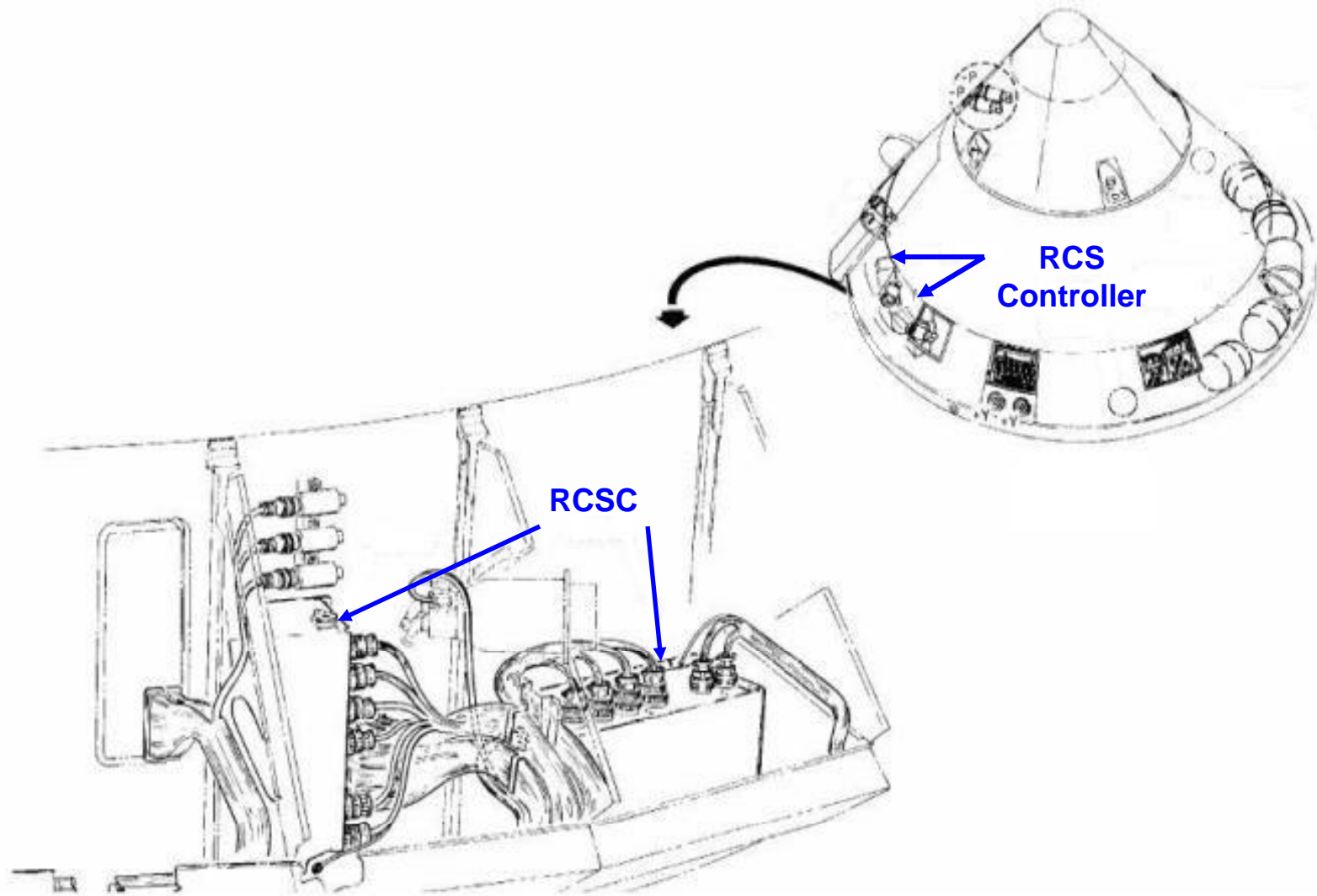
SEQUENTIAL EVENTS CONTROL SYSTEM SYSTEM A ONLY



MESC & ELSC Location in CM



RCSC Location in CM

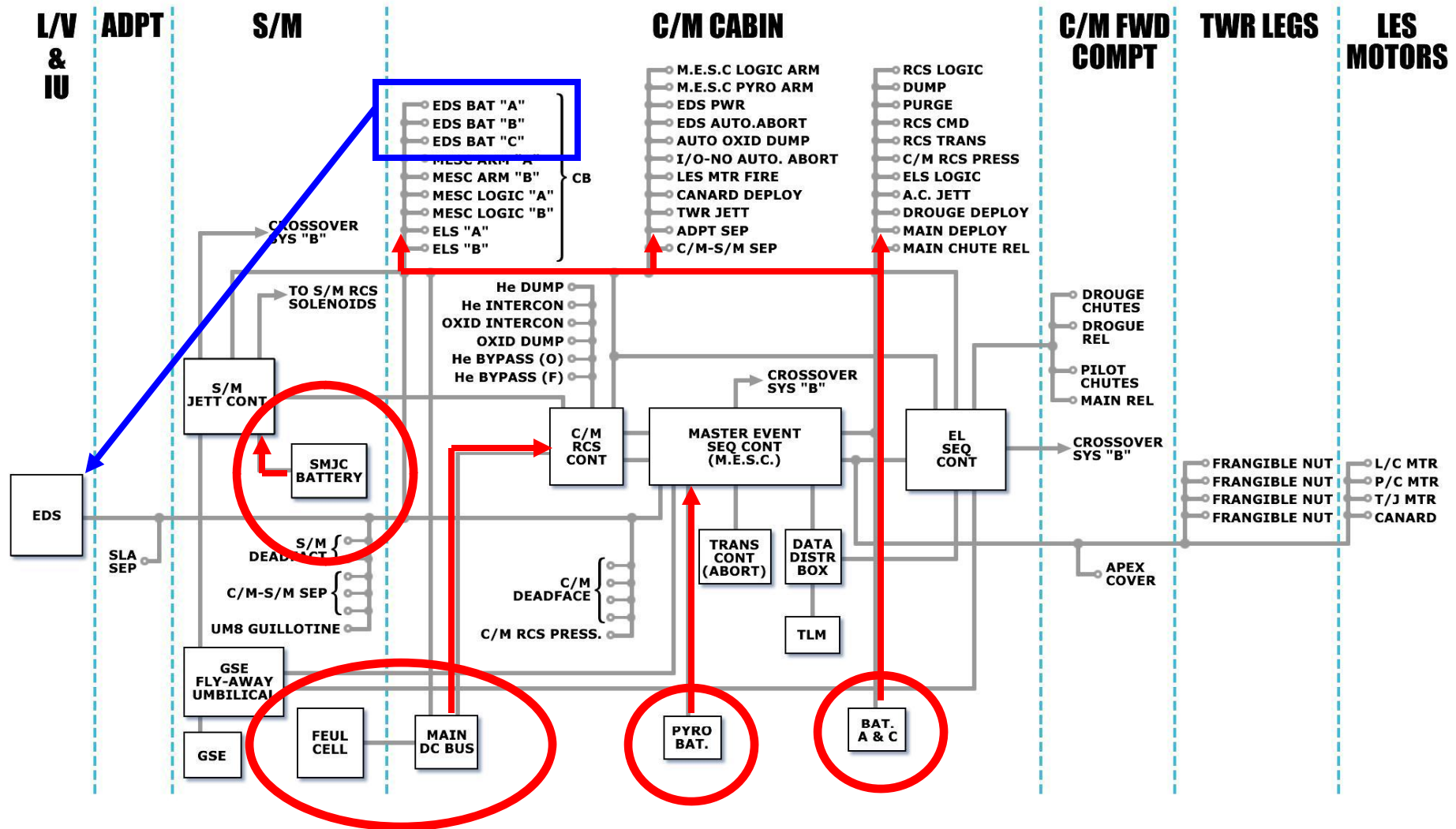


SECS Power Requirements

- ❑ DC power provided by a total of 5 batteries on board CM
- ❑ Batteries A, B provide Logic Bus power SECS A and B, respectively
- ❑ Batteries A, B, and C combined provide three legs of logic power required for EDS
- ❑ All three batteries rechargeable in flight by spacecraft power buses
- ❑ Two Pyro batteries supply power to Pyro Busses - not rechargeable
- ❑ Main DC power supplied by fuel cells in SM for CM RCSC
- ❑ Two additional batteries in SM power SMJC after CM/SM separation - not rechargeable

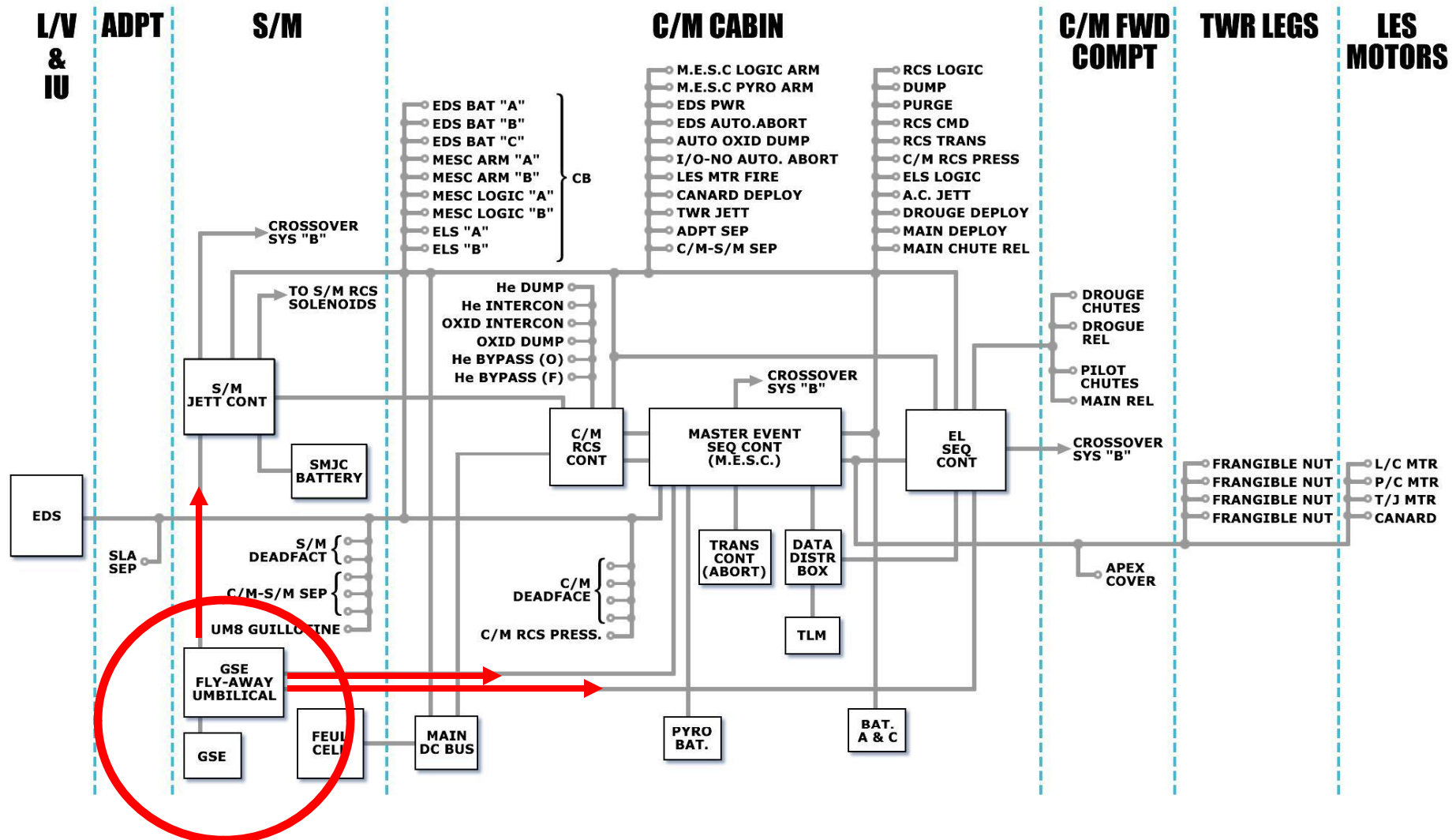
SECS Power Requirements

SEQUENTIAL EVENTS CONTROL SYSTEM SYSTEM A ONLY

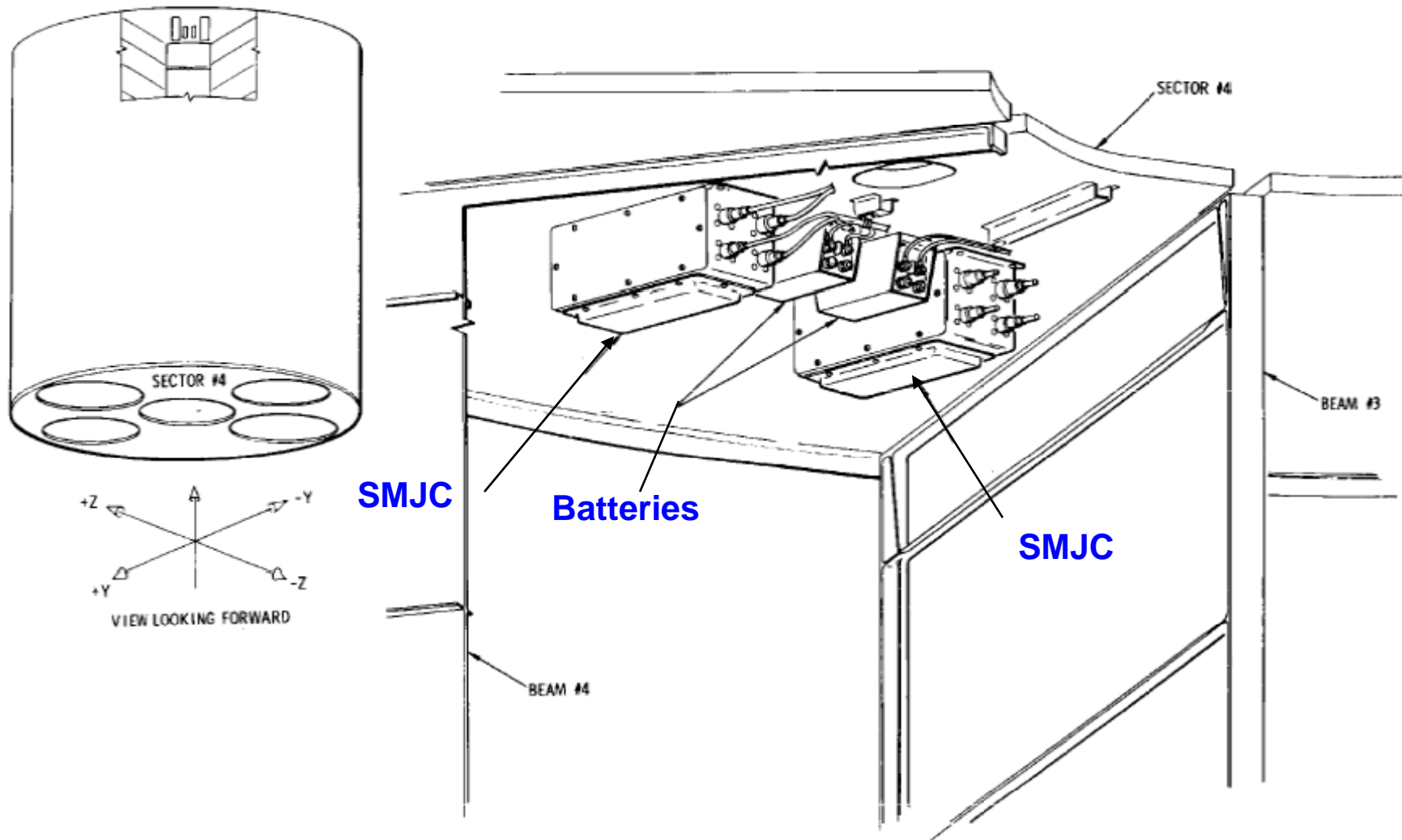


SECS Power Requirements

SEQUENTIAL EVENTS CONTROL SYSTEM SYSTEM A ONLY



SMJC Locations



SECS Additional Components

- ❑ Various circuit breakers, switches, and indicators on main display and control panel in CM
- ❑ Powered by batteries A, B, and C
- ❑ On launch pad, Acceptance Checkout Equipment (ACE) and GSE used for integrated system checkouts, via GSE Flyaway Umbilical

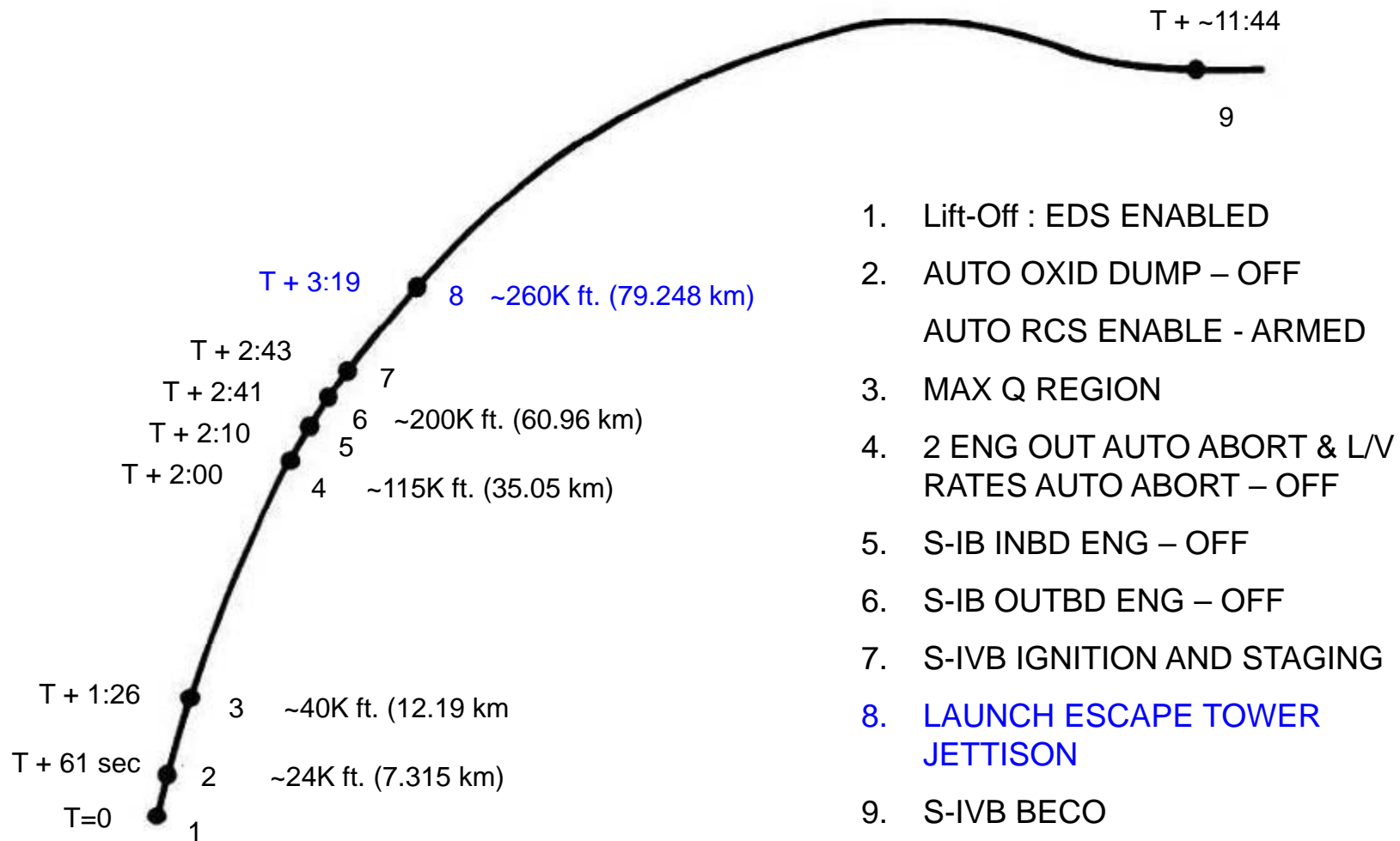
SECS Functions

- ❑ SECS armed one hour prior to launch and remains energized until after adapter separation. (~3 hours GET)
- ❑ Turned on again for CM/SM separation on pre-entry and remains energized until after main chutes released

Nominal Functions include:

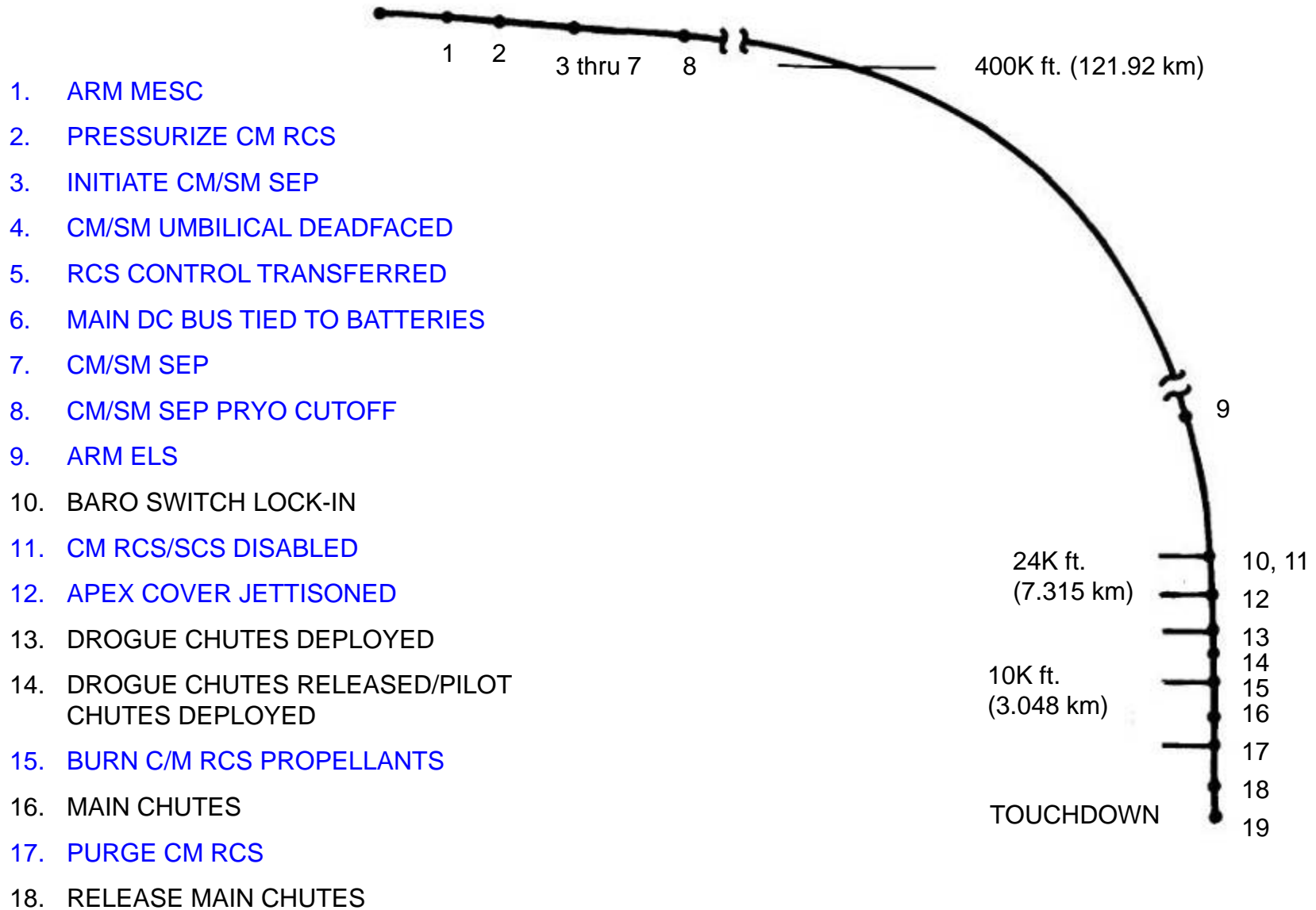
- ❑ Launch Escape Tower (LET) Jettison
- ❑ Spacecraft/LM Adapter (SLA) Separation
- ❑ CM/SM Separation and Connection Dead-facing
- ❑ SM Jettison
- ❑ Parachute Deploy
- ❑ Additional Abort Functions

Nominal Ascent Events Profile



1. Lift-Off : EDS ENABLED
2. AUTO OXID DUMP – OFF
AUTO RCS ENABLE - ARMED
3. MAX Q REGION
4. 2 ENG OUT AUTO ABORT & L/V
RATES AUTO ABORT – OFF
5. S-IB INBD ENG – OFF
6. S-IB OUTBD ENG – OFF
7. S-IVB IGNITION AND STAGING
8. LAUNCH ESCAPE TOWER
JETTISON
9. S-IVB BECO

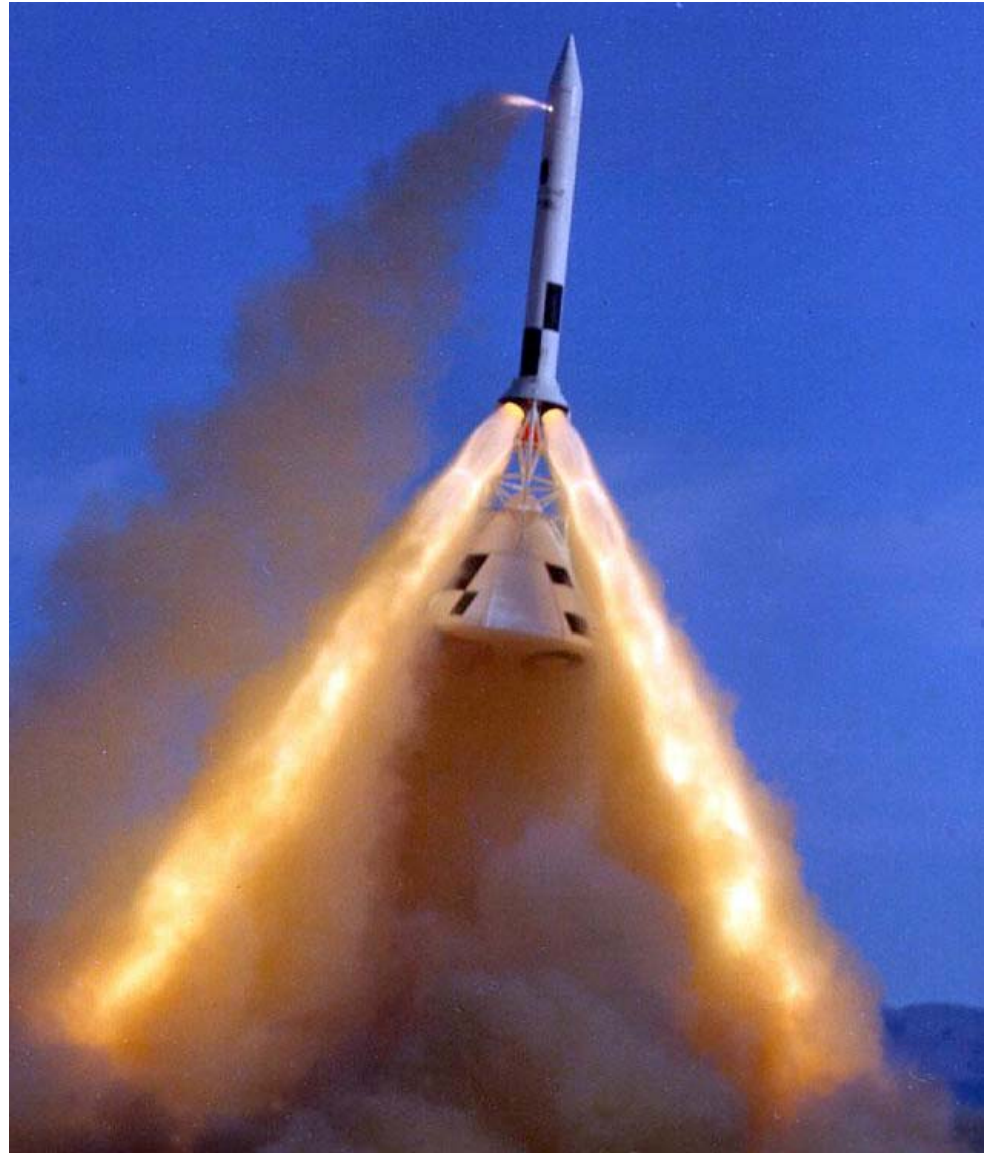
Nominal Entry Events Profile



A Quick Word on Aborts

Launch Escape System Aborts

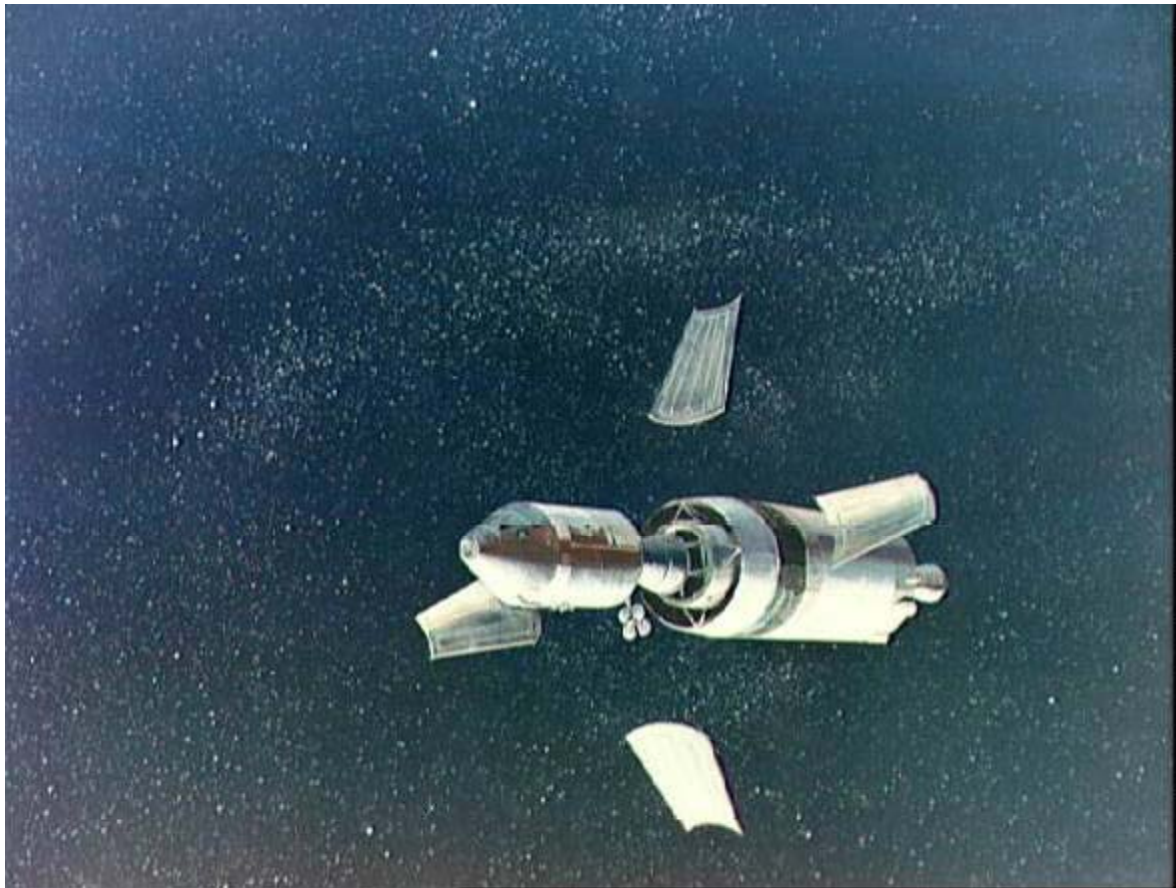
- ❑ Utilizing the Launch Escape Tower (LET) to provide crew with an instantaneous means of escape. Effective anytime while on the launch pad until LET jettison (approximately 3:19).



A Quick Word on Aborts

Service Propulsion System Abort

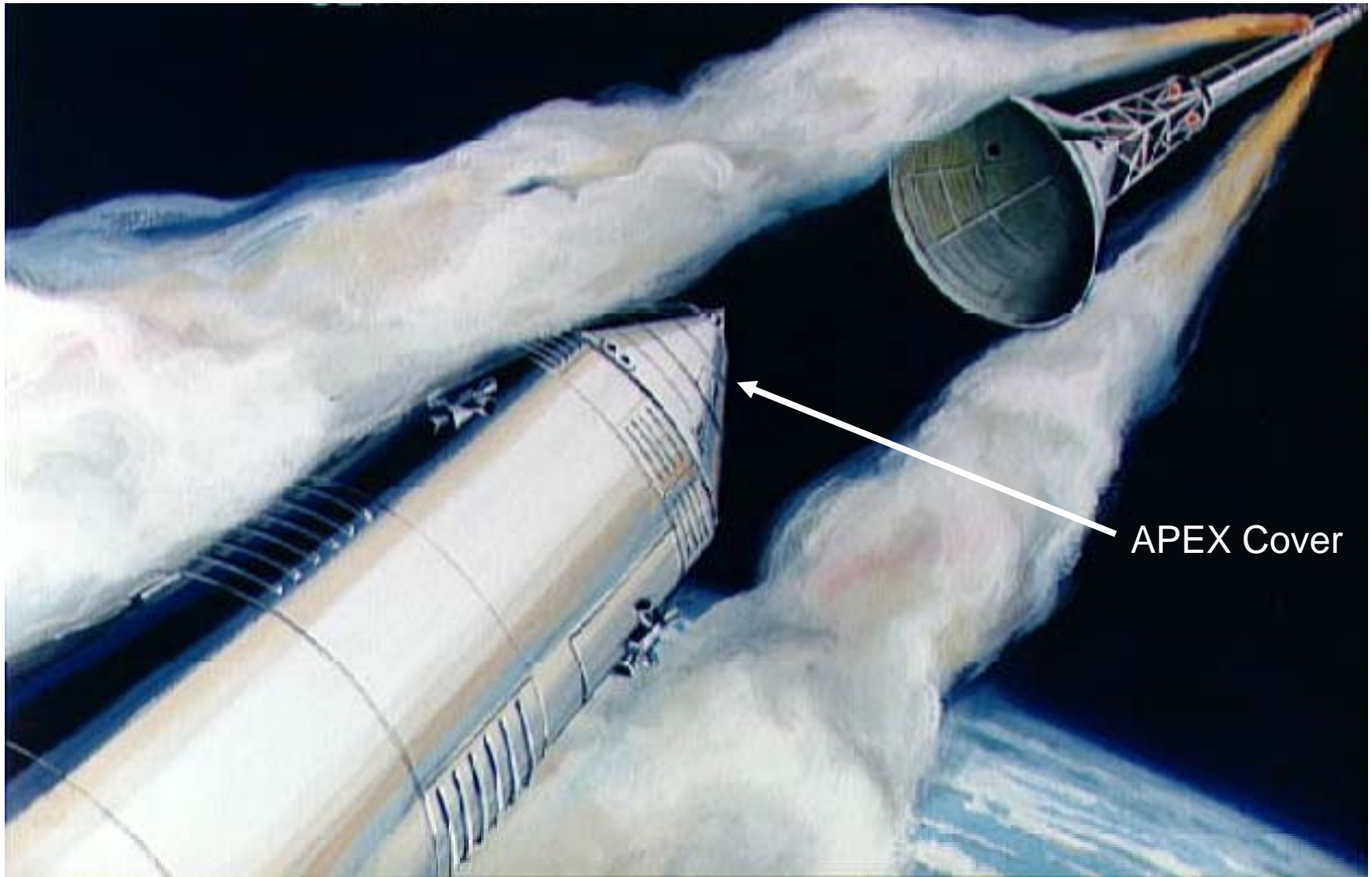
- ❑ Utilizes the SM's propulsion system. Initiated during powered flight, anytime between LET jettison and Adapter separation (nominally ~ 3 hours into mission). Decision made real-time to abort to orbit or return to earth.



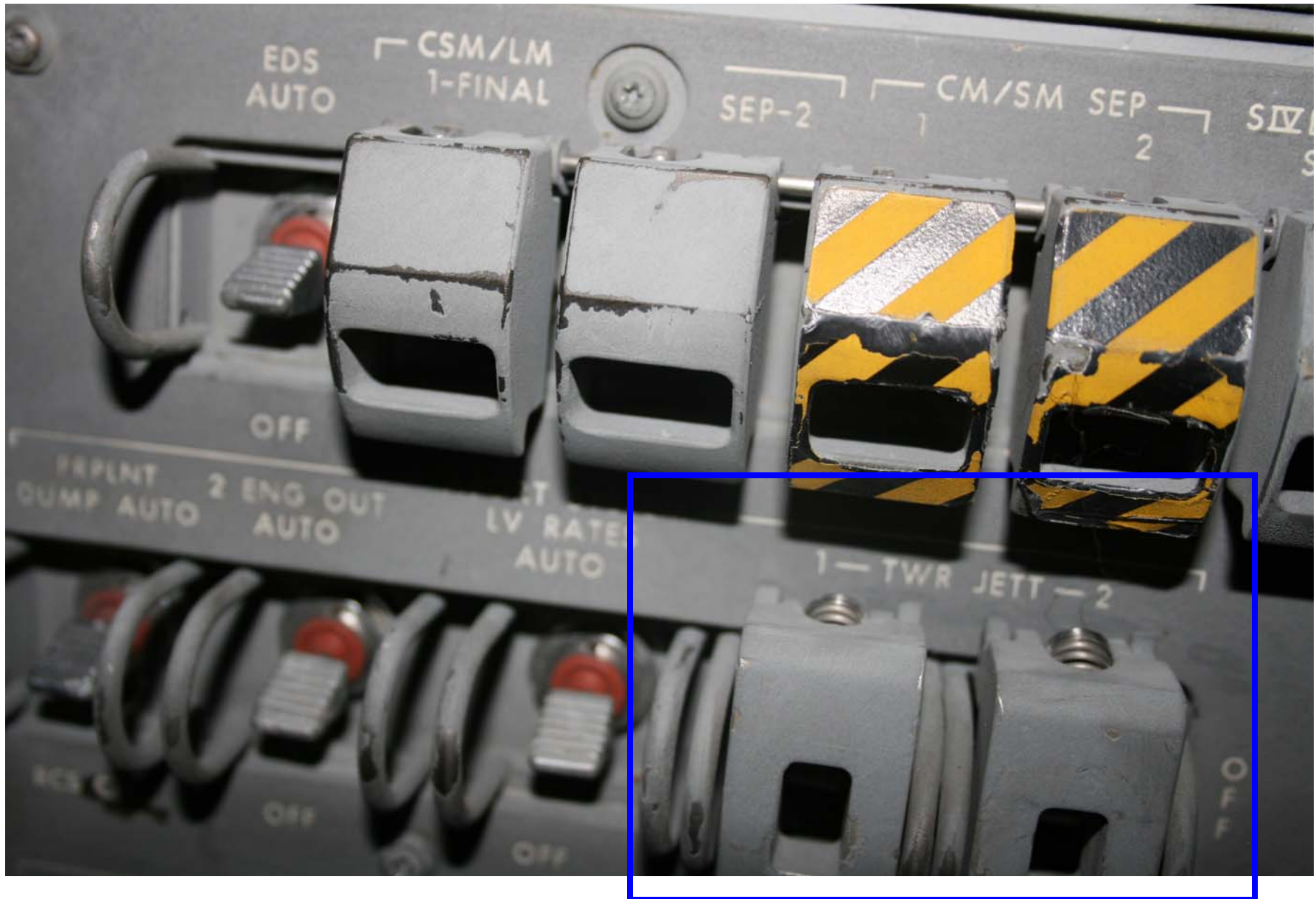
Launch Escape Tower (LET) Jettison

- ❑ LET is part of the Launch Escape System (LES) which provides the means for the crew to escape instantaneously from the launch vehicle in the event of an abort, either while on the launch pad and anytime up until the end of first stage.
- ❑ SECS acts as the controlling agent, via the MESC, for LET jettison. Function is manually initiated by the crew following first stage staging and ignition of the second stage, and also during some aborts. During all LES aborts, the LET is jettisoned automatically by the MESC with the time of jettison being controlled by the 24,000 foot ELS baroswitches.

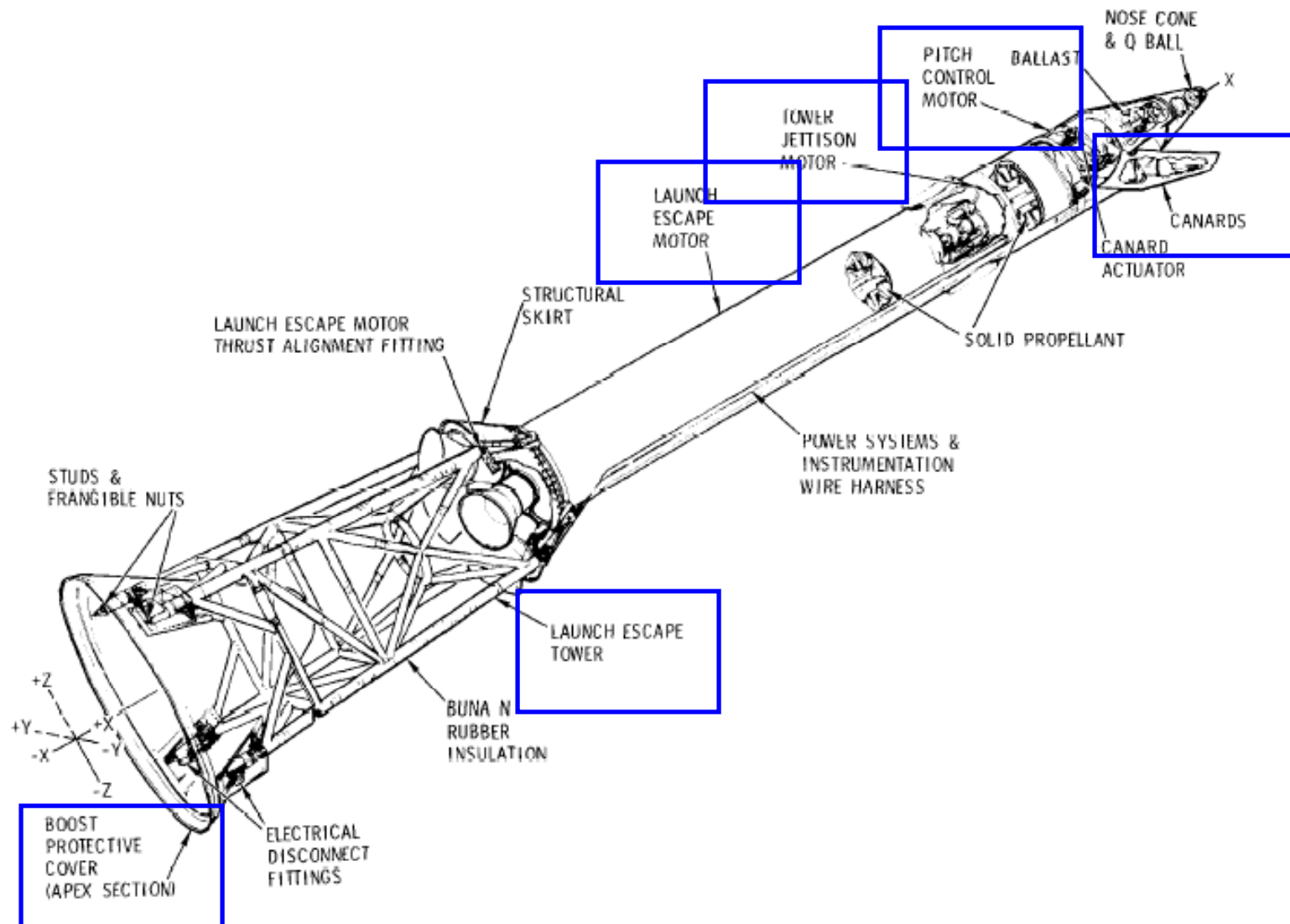
LET Jettison



LET Jettison



Launch Escape System (LES)



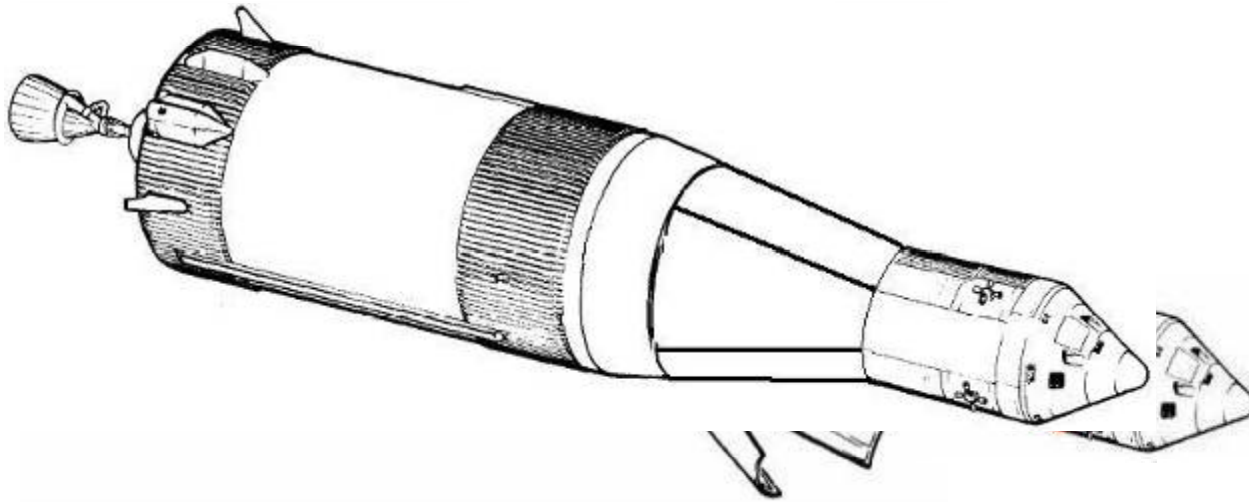
Spacecraft/Lunar Excursion Module/Adapter (SLA) Separation

SECS performs the nominal SLA separation task once initiated by the crew (~ 3 hours into mission)

- ❑ Commander manually enables the CM RCS/SCS (RCS CMD – ON)
- ❑ Then initiate a +X translation with the Translation Controller
- ❑ Approximately 2-3 seconds later he will manually initiate adapter separation which utilizes MESC components



SLA Separation



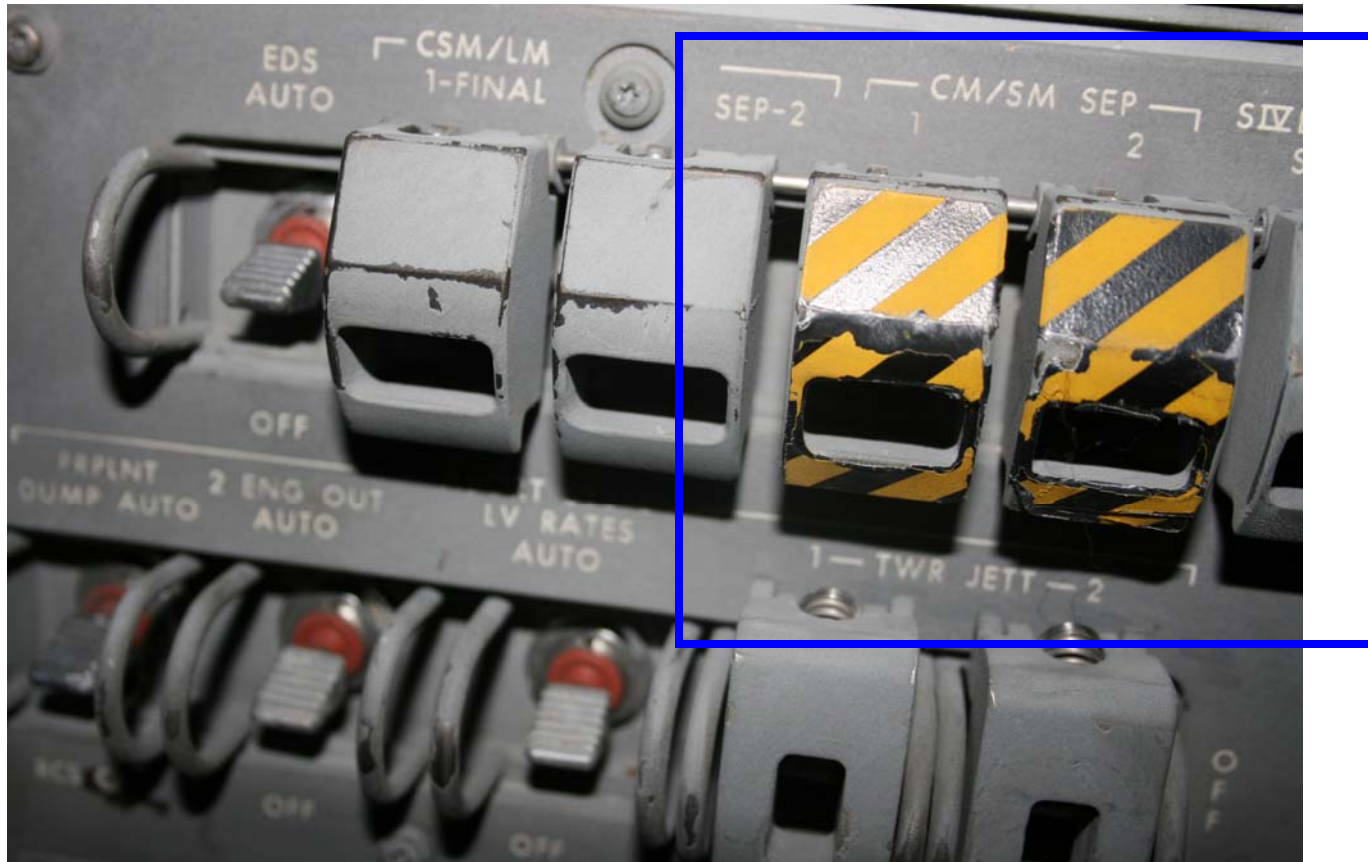
Spacecraft/LM Adapter (SLA) Separation

- ❑ Emergency separation of the SLA is performed automatically following the manual initiation of an SPS abort anytime between nominal LET jettison and nominal SLA separation. During this abort, the following functions are performed automatically by the MESG:

- BECO (Booster Engine Cut-off)
- Direct SC ullage started
- Guidance and Navigation signaled of SPS abort
- Event Timer Reset
- SLA separated
- SM RCS/SCS enabled for rate stabilization

CM/SM Separation & SM Jettison

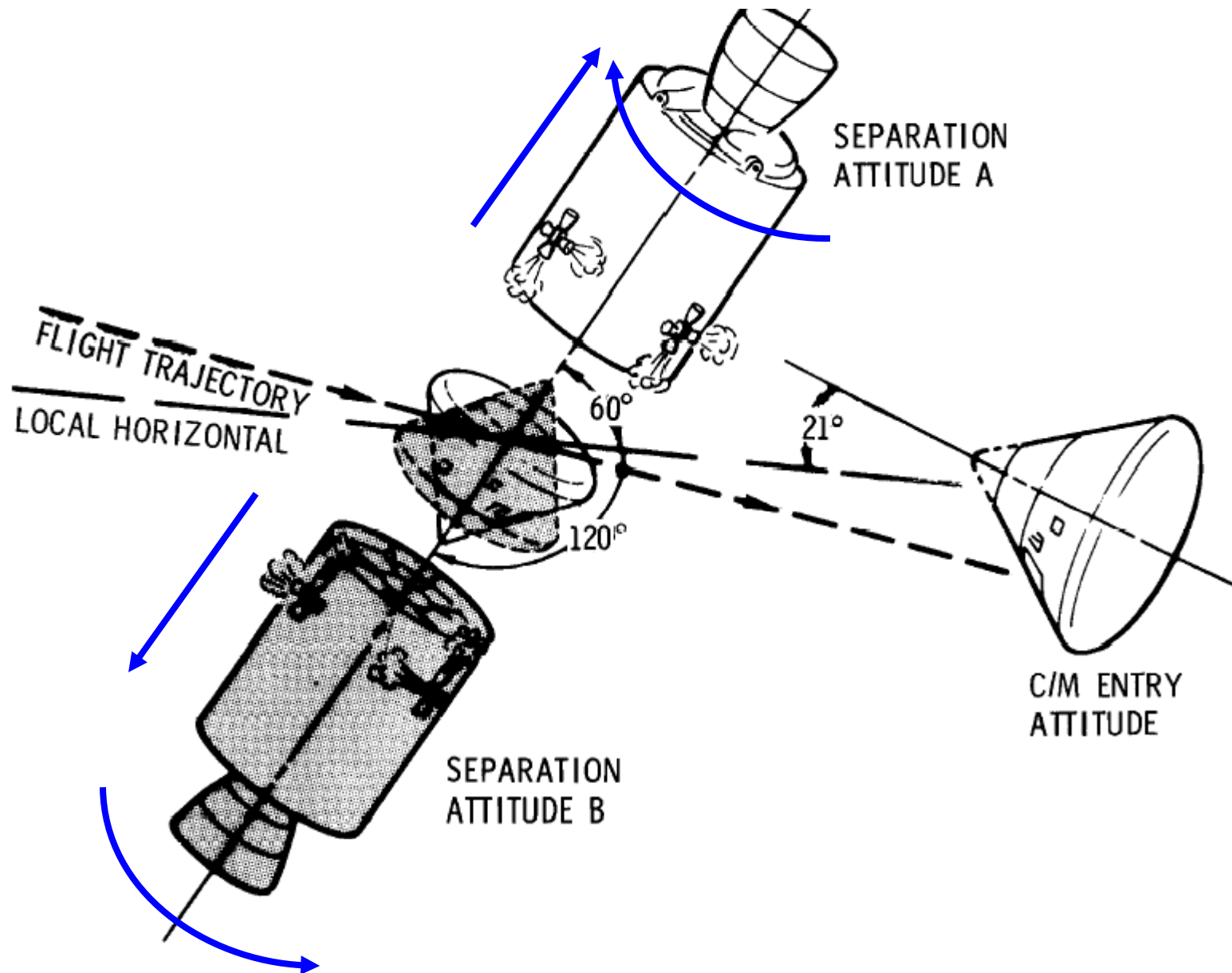
- ❑ CM/SM separation is performed by MESC and occurs during entry following a nominal end of mission or an SPS abort
- ❑ Manually initiated command from the crew (Switches on Panel 02)
- ❑ Same command also energizes the SM Jettison Controller which affects the retrograde and roll-out maneuver of the SM away from the CM



CM/SM Separation & SM Jettison

- ❑ Separation function is performed automatically by the MESC on LES abort
- ❑ After CM/SM separation, RCS control is transferred from the SM to the CM by two motor switches in the CM RCSC, being driven by a signal from the MESC
- ❑ Automatic backup switching power for tying the CM batteries to the Main DC Bus is directed across a set of contacts in each of these motor switches

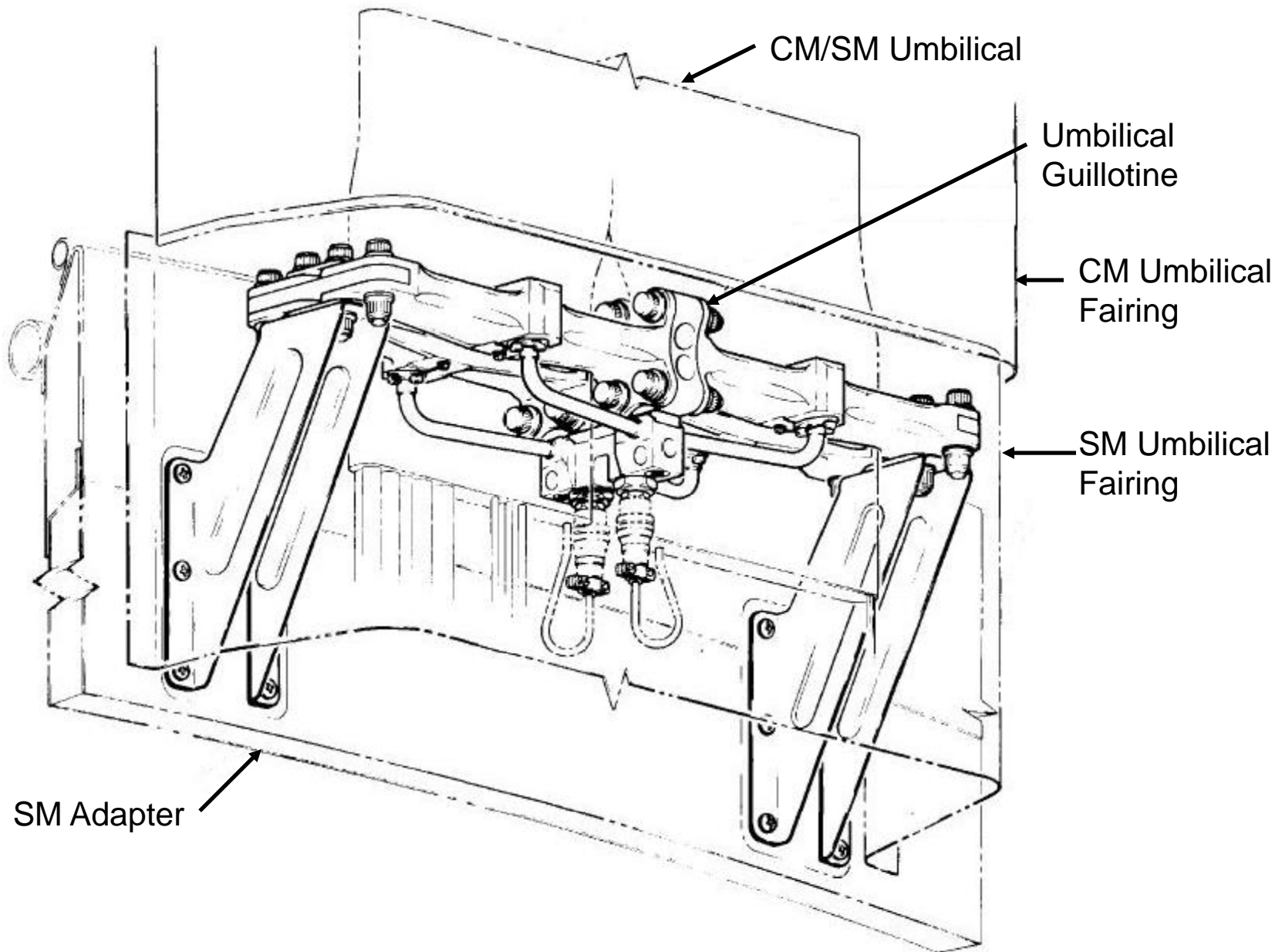
CM/SM Separation & SM Jettison



CM/SM Dead-facing

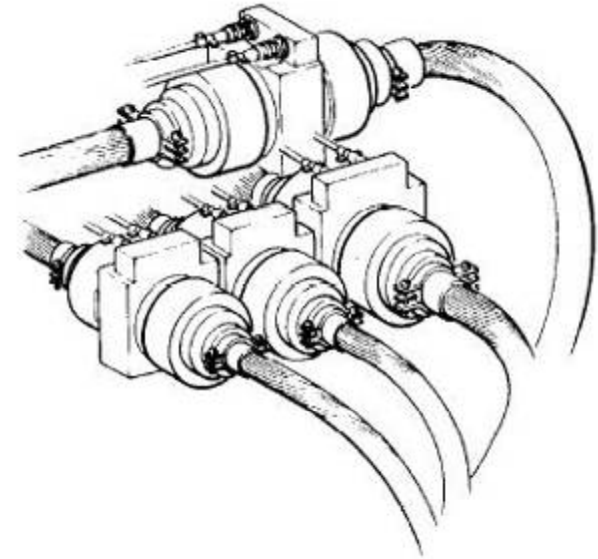
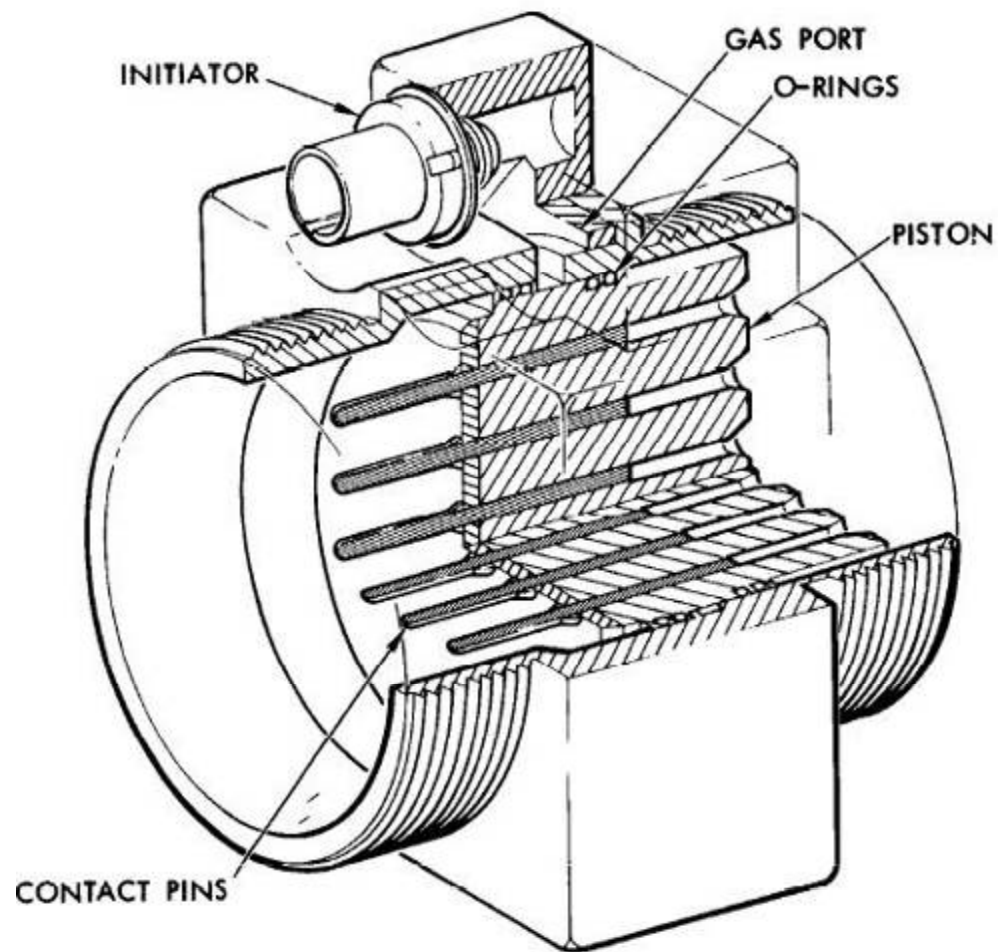
- ❑ Part of the CM/SM separation process is the destruction of the CM to SM wiring umbilical. A prerequisite to this action is to 'open' certain circuits known to be hot. To accomplish this, circuit interrupters are fired by the MESC to dead-face these hot circuits anytime the CM is separated from the SM.
- ❑ Also following the initiation of the CM/SM separation, whether in the nominal end of mission phase or subsequent to an SPS or LES abort, the pyrotechnic circuits for separating the CM from the SM are dead-faced by de-energizing the separation relays. This function prevents any possibility of a high resistance short to ground within the separation system from discharging the Pyro batteries before deployment of the Main Landing parachutes.

CM/SM Umbilical Deadfacing



CM/SM Umbilical Deadfacing

Electrical Circuit Interrupters



Earth Landing System (ELS)

- ❑ The Earth Landing System (ELS) is utilized automatically by the SECS following a nominal end of mission entry, or for subsequent functions to an LES or an SPS abort. The ELS includes the drogue, pilot, and main landing parachutes.
- ❑ The ELS Logic Bus is armed manually during a nominal entry or following an SPS abort with return to earth prior to descending to an altitude of approximately 50,000 feet, but is not activated automatically until closure of the 24,000 foot baroswitch contained within the ELSC.
- ❑ During all LES aborts, the ELS is armed automatically by the MESC fourteen seconds after the initiation of the abort and activated with closure of 24,000 foot baroswitches.
- ❑ Subsequent functions of the ELS are dependent upon these 24,000 foot baroswitches, some 10,000 foot baroswitches and time delays.

Parachute Deploy

- ❑ Drogue parachutes are deployed automatically by the ELSC firing mortars 1.6 seconds after the Apex Cover is jettisoned. Drogue chutes are released automatically as the pilot chutes are deployed, which are automatically deployed by the ELSC firing mortars.
- ❑ Main Landing parachutes are deployed by the use of these small Pilot parachutes. During a nominal descent, the Pilot parachutes are deployed when the 10,000 foot baroswitches close in the ELSC.
- ❑ The ELSC also fires the parachute release mechanisms. The Main Landing parachutes are released only after the crew initiates their release manually after touchdown on the water.

Parachute Deploy



Emergency Detection System (EDS)

- ❑ The Emergency Detection System (EDS) contained within the launch vehicle provides inputs to and interfaces with the SECS.
- ❑ An EDS automatic abort may be voted within the Master Events Sequence Controller (MESC) of the SECS at anytime from liftoff until tower jettison when this capability is automatically switched off, or until inhibited by the crew's switching functions.
- ❑ The EDS automatic abort capability is armed by the crew prior to launch, but is not enabled automatically by the MESC until lift-off.
- ❑ An EDS automatic abort is initiated by abort voting relays within the MESC when certain conditions are satisfied within the EDS.

Translation Controller

- ❑ The Translation Controller provides the Commander (left side) with the means to manually initiate an LES or an SPS abort.
- ❑ LES abort may be manually initiated by the Commander while on the launch pad after the SECS is armed, or at anytime during ascent until the LET is jettisoned.
- ❑ After the LET is jettisoned, there is no longer any possibility for an EDS automatic abort, as previously stated, and therefore an SPS abort must be manually initiated by the Commander.

Translation Controller



Additional SECS Functions

- ❑ Resets Digital Events
the timer is reset to zero
functions during the abort
started from zero at liftoff
- ❑ Initiates Booster Engine
initiate the shutdown
Safety specifies that for
Booster Engine Cut-Off
time delay in the Instr
MESC attempts to shut



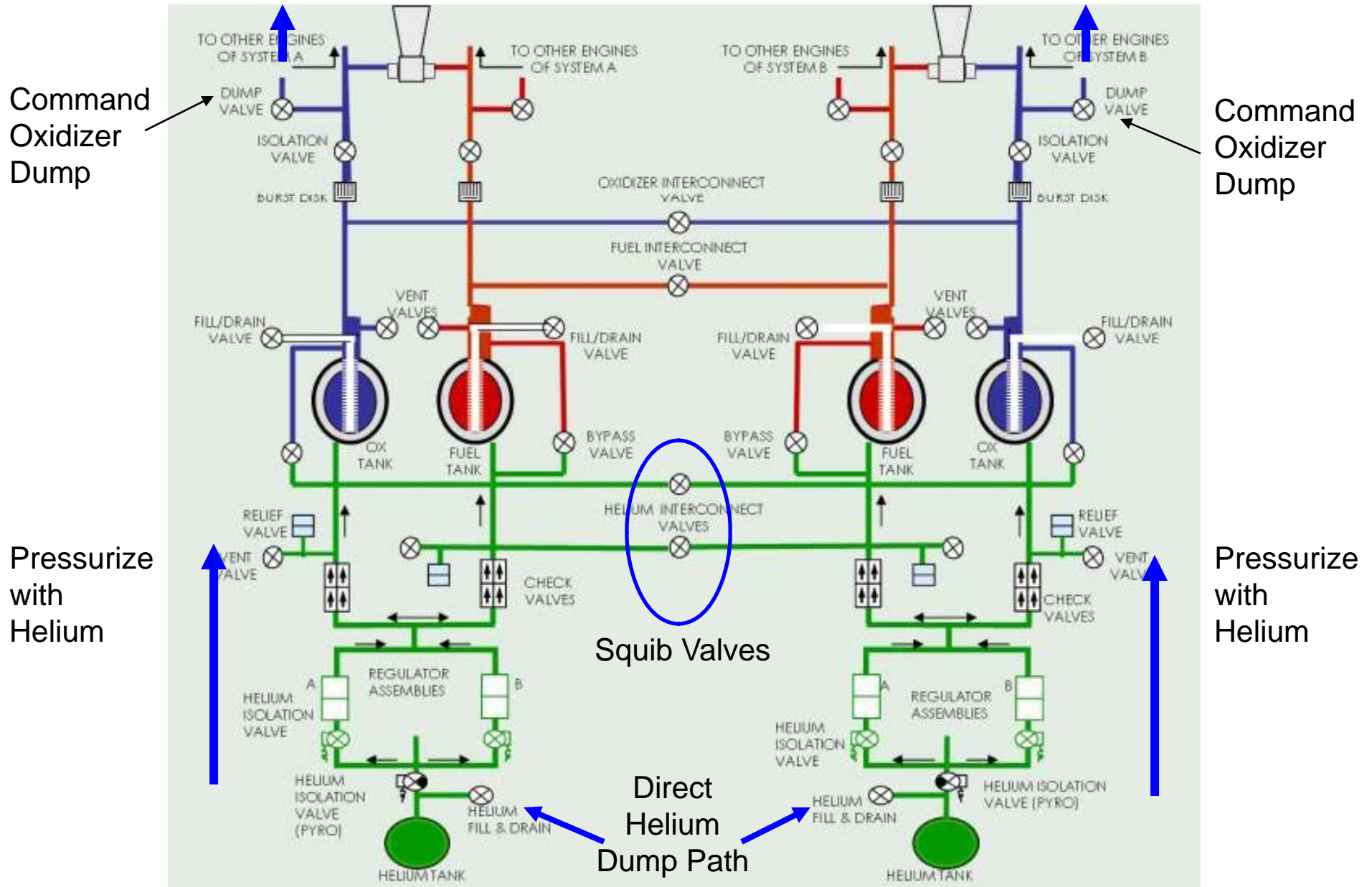
on initiation of an abort
le the crew to monitor
igital Readout is

C contains relays which
ation of aborts. Range
f time following liftoff,
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Additional SECS Functions

- ❑ Pressurizes the CM RCS – When an LES abort has been initiated, it is mandatory that the CM's RCS be pressurized with helium, either for disposal of the propellants or for utilizing the RCS for stabilization or orientation. The MESC handles this function immediately upon abort initiation or when commanded manually before CM/SM separation on pre-entry.
- ❑ Commands CM RCS Oxidizer Dump – If the 61 second timer in the CM RSCS that is used for controlling automatic Oxidizer dumping has not timed out after being energized at lift-off, the CM's RCS Oxidizer will be dumped with the energizing of the Oxidizer Dump relays in the RCSC. When an LES abort has been initiated, these relays are energized by an output signal from the MESC. At the same time, the Helium and Oxidizer Interconnect Squib valves that are between the oxidizer supply tanks are fired by other relays within the RSCS to affect this operation thoroughly.
- ❑ It is also desired to always dispose of the Helium, either by purging the RCS, as on a nominal descent or aborts after 61 seconds from lift-off, or by dumping it directly from the supply tanks when time critical. For LES aborts from the pad up to 61 seconds from lift-off, when time is most critical, the helium will be dumped automatically 18 seconds after the abort was initiated and the full fuel load will remain on board the CM. There will be no manual switching functions required of the crew concerning the SECS during this type of abort, unless for back-up purposes. Every function is performed completely automatically.

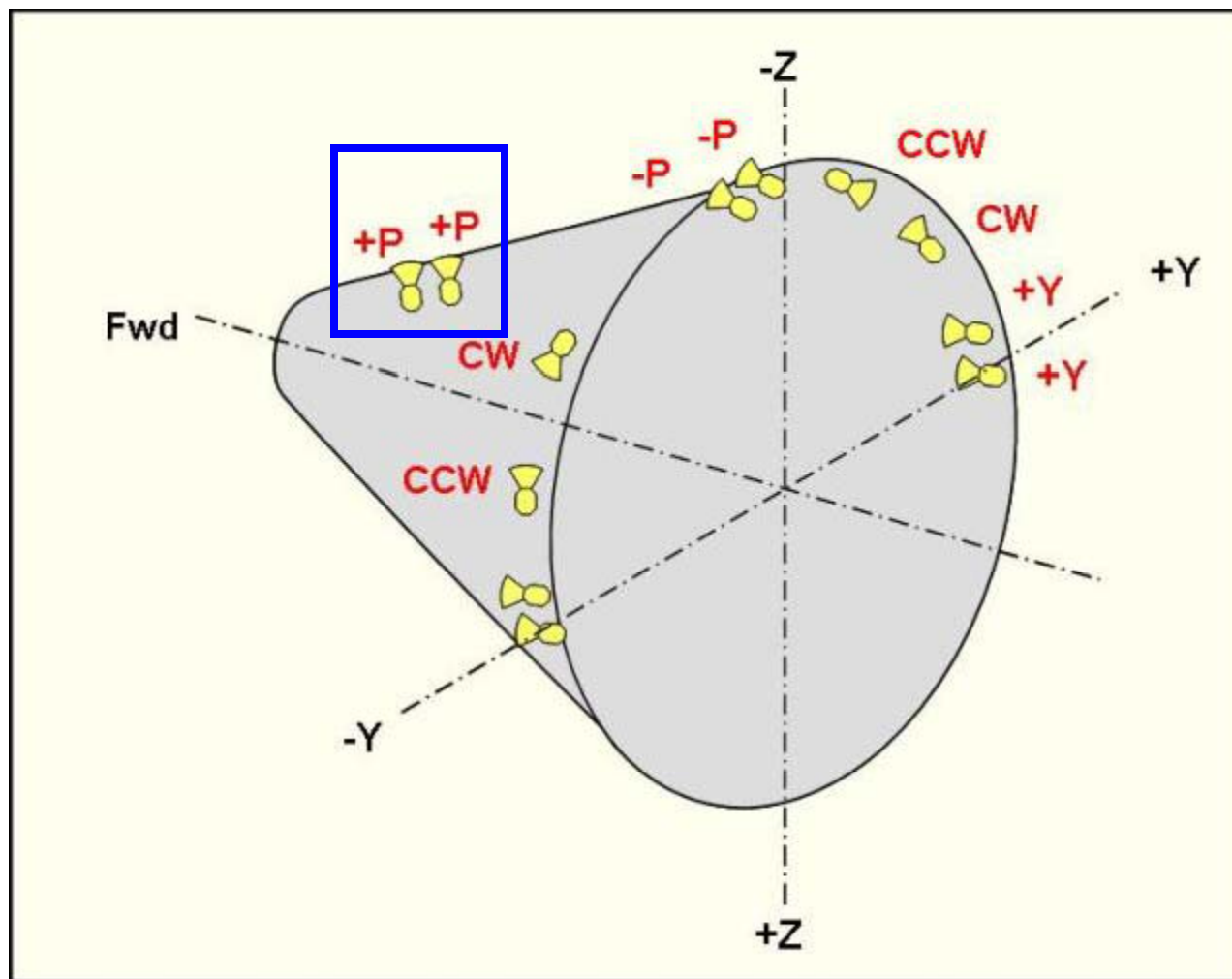
Additional SECS Functions



Additional SECS Functions

- ❑ Controls CM RCS Propellant Disposal – During nominal descents after main landing parachute deployment, the Commander will dispose of all remaining RCS propellants on board the CM by burning it off through the simultaneous firing of all the RCS engines, except the positive pitch engines.
- ❑ For any LES abort after 61 seconds from lift-off, the full load of propellants is disposed of by burning. For LES aborts from the launch pad or up until 61 seconds from lift-off, however, the oxidizer is always dumped automatically in the first 11-12 seconds during the abort ascent phase.

CM RCS Locations



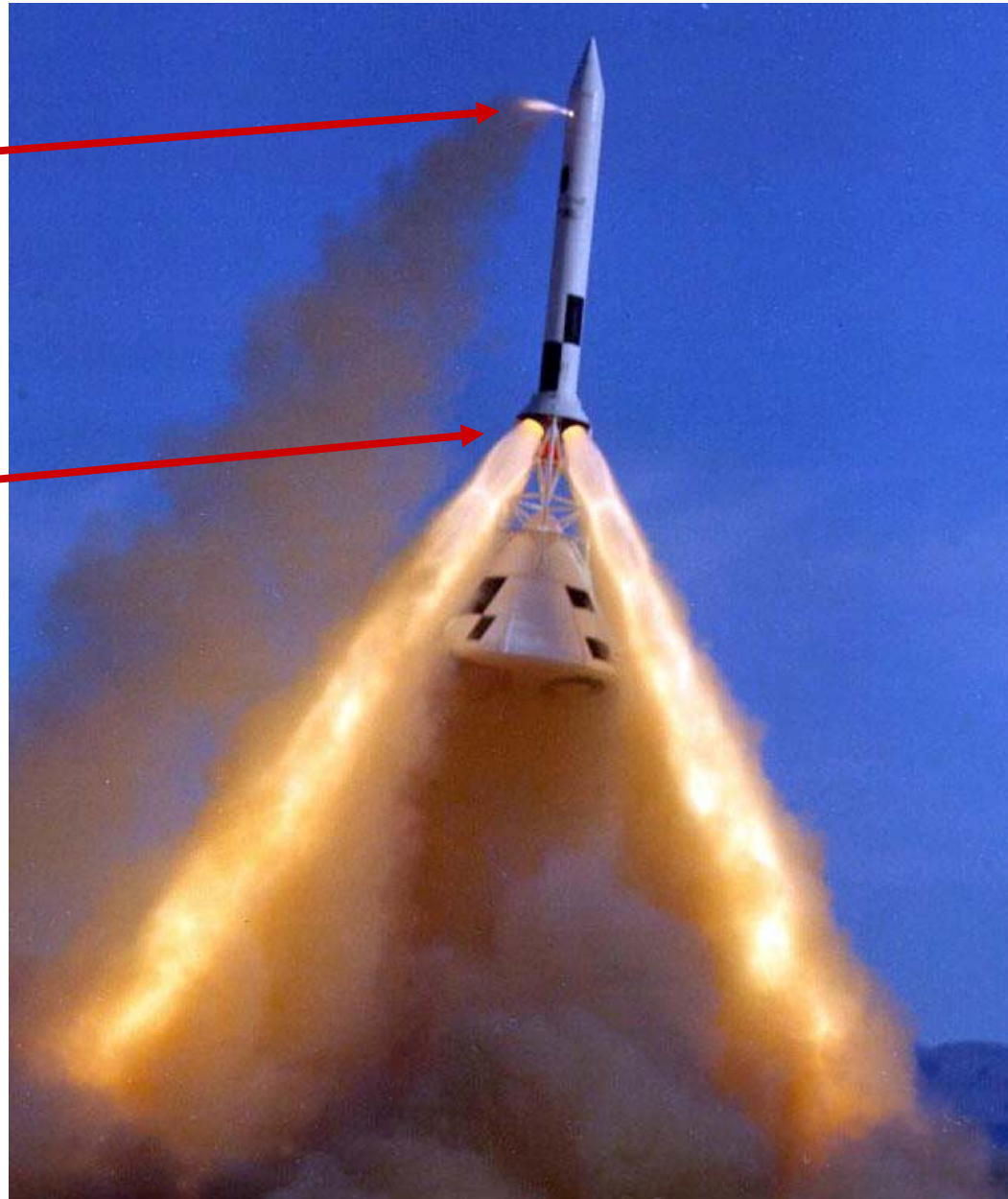
Additional SECS Functions

- ❑ Ignites LES Rocket Motors for LES Abort – Immediately following the initiation of an LES abort, either from the pad or up until 61 seconds from lift-off, the MESC ignites the Launch Escape and Pitch Control motors simultaneously to propel the Launch Escape Vehicle (LEV) away from and into a different trajectory than that of the boost trajectory. After 61 seconds from lift-off, however, the possibility for igniting the Pitch Control motor is automatically switched out by the time-out of the 61 second automatic oxidizer dump time delays, thereby making it impossible for the Pitch Control motor to be ignited in case of an LES abort between that time and tower jettison.
- ❑ Deploys Canards – The Canards are deployed automatically by the MESC eleven seconds after the initiation of an LES abort.
- ❑ Jettisons Apex Cover – The Apex Cover is jettisoned automatically by the MESC, but dependent upon the 24,000 foot baroswitches in the ELSC. The Apex Cover is jettisoned 0.4 seconds after the LET is jettisoned at 14 seconds after the initiation of an abort below 30,000 feet. For any abort above 30,000 feet or for a nominal entry after a successful mission, the Apex Cover is not jettisoned automatically until after descending to approximately 24,000 feet

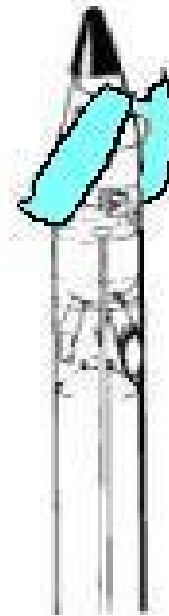
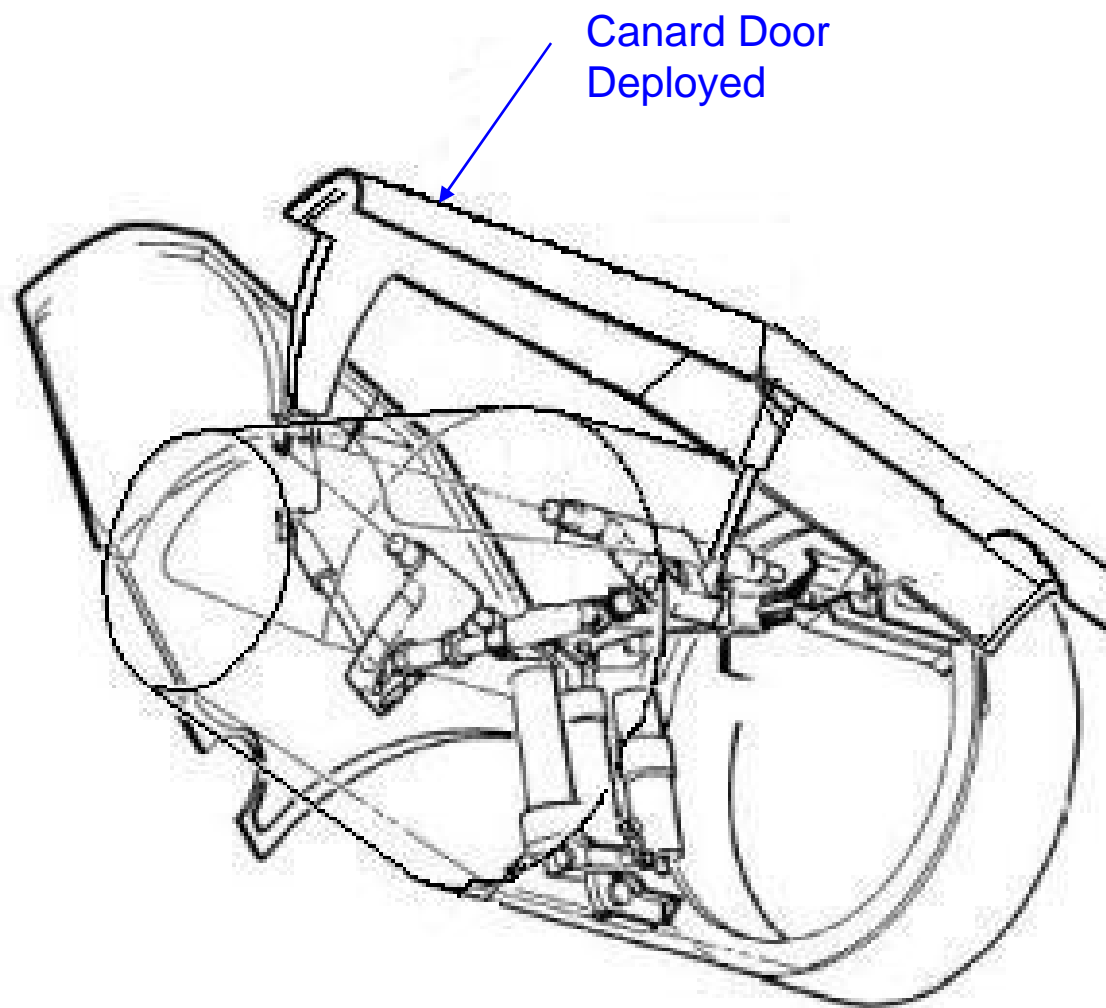
Ignites LES Rocket Motors for Abort

Pitch
Control
Motor

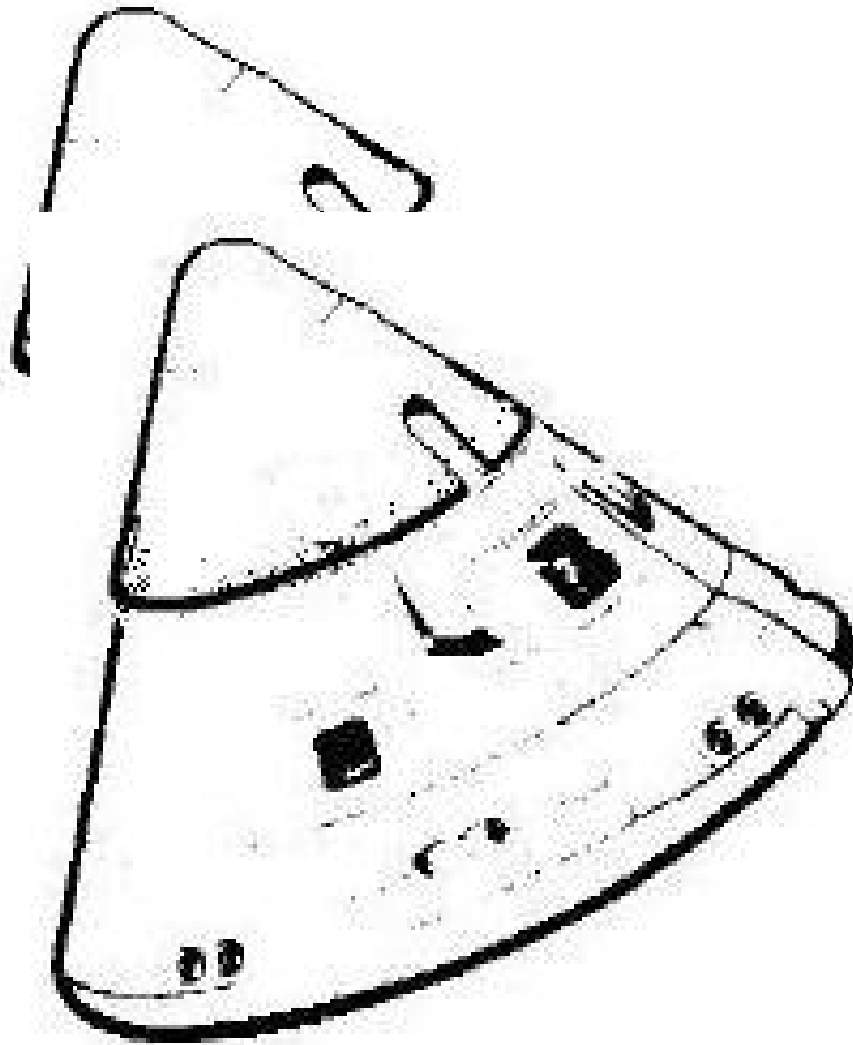
LES Rocket
Motor



Deploy Canards



APEX Cover Jettison



Additional SECS Functions

- ❑ Vital Information Downlisted – The SECS provides conditioned signals to the telemetry equipment through the Data Distribution Box so that certain vital information may be downlisted to the Manned Space Flight Network (MSFN). This vital information is events which take place from the time the crew activates the SECS until completion of the mission, used by ground personnel in determining the status of the mission.

Special Thanks

We would like to extend special thanks to the **Kansas Cosmosphere and Space Center** for providing excellent photographs of the panels of the Lunar Module Trainer, from which many of the graphics in this lesson were drawn.



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